REMARKS

The Applicant request entry of the amendments set forth above. Claims 1-26 as filed are pending. In the Office Action mailed May 15, 2007, the Examiner rejected Claims 1-11 and 13-26 and objected to Claim 12. The Examiner also objected to paragraph 0079, which Applicants submit should be an objection to paragraph 060. In response, the Applicants have amended Claims 1-9, 11, 17, 24, and 26 and provided the remarks that follow for consideration by the Examiner. The Examiner's objections and rejections are addressed below.

Objection to the Specification

The Examiner objected to paragraph 0079. Upon review of this paragraph, the Applicants submit that perhaps the Examiner intended to object to paragraph 060. The Applicants have amended paragraph 060 and submit that this amendment overcomes the Examiner's objection to the specification.

Claim Rejections Under 35 U.S.C. § 102

The Examiner rejected Claims 1-10, 17-18, 22, and 24-26 as being anticipated by the Cioffi reference (U.S. Patent # 5,995,567). From this claim set, Claims 1, 6, 17, and 24 are independent claims. Each of the independent claims is discussed below. Prior to discussing the amendments to the independent claims, a technical discussion of the claimed invention is presented to aid the Examiner.

Technical Discussion

Cioffi Patent

The Cioffi reference discloses a system that is different then the system as claimed. In particular, the Cioffi reference discloses filtering a single common mode signal and subtraction into a single differential mode signal as is evident by the following observations:

- Fig. 2, which describes the basic architecture only shows a single common mode signal (110) and a single differential signal (108). The same is true for all other figures (Fig. 1 and Figs. 3-6).

- Throughout the specification section, the patent always talks about a first signal, a reference noise signal (col. 3, ln. 43-52), a transformer (col. 3, ln. 53-65). Nowhere does the patent talk about two or more signals, or two or more transformers. Also, the Cioffi reference does not provide even the slightest suggestion of a multipair system, or that if applied to a multipair system, that anything should be done differently (e.g., joint filtering of all common mode signals, as the current application teaches).

- In the claims section, all claims refer to "a first signal", "a second signal", "an adaptive filter", "a subtractor" etc. (e.g., Claim 1). Nowhere in the claims section of Cioffi, does the invention envision noise cancellation across multiple pairs.

The Examiner asserts that the Cioffi reference talks about multichannel systems in the context of DMT/multicarrier modulation (col 4, ln. 4-6). However, in this context, the Cioffi reference's discussion of multichannel actually means and refers to frequency bins (channels) not multiple pairs. The noise cancellation structure implemented for a particular carrier (i.e. channel or frequency bin) can be replicated to a second carrier (i.e. channel or frequency bin) or to all carriers/channels of the DMT modem. No teaching of a multi-pair system is provided in Cioffi.

However, the multichannel architecture of the present application is not referring to "frequency carriers" or frequency bins when talking about multiple "channels". Instead, the multichannel system as claimed means multiple physical channels. For example, the channels may comprise to multiple "pairs" of conductors and therefore, to multiple differential signals, multiple transformers and multiple common mode signals (e.g., Fig. 17). This is quite different from the Cioffi reference's disclosed architecture.

Present Application

In reference to Figure 17A of the present application, each incoming signal is output from the AFE 1704. This incoming signal, in reference to Channel 0, is sent to both the differential mode signal isolation unit 1708A and to the common mode signal isolation unit 1712A. The common mode signal isolation unit 1712A outputs the common mode signal to each filter 1720 as shown. Each filter 1720 receives the common mode signal from each of the other channels. Thus, filter 1720A receives the common mode signal from Channel 0 – Channel M. The filter 1720A, and each of the other filters 1720, jointly processes the common mode signal from each channel to generate a cancellation signal. Each cancellation signal is then routed back to junction 1716 to cancel unwanted interference in the differential mode signal associated with the signal on that channel.

Processing each common mode signal in each filter 1720 provides non-obvious differences and advances over the teaching of the Cioffi patent. By way of example, all common mode signals from the various multiple channels are jointly processed. This is quite different from a mere replication of the Cioffi of Amrany systems on multiple instances. It provides a more powerful characterization of the components of the interfering signal and results in cancellation of multiple noise sources at the same time, something that the Cioffi and Amrany inventions cannot achieve.

On a single pair, the received differential voltage v_d may contain two components,

$$v_d = s + i \qquad (1)$$

a useful signal s and an interference component i. It is also possible to sense the common mode voltage, which is correlated to the interference. In this example, the common mode voltage is defined as,

$$v_c = ai \qquad (2)$$

where a is a non-zero scalar. From equations (1) and (2) that if one can sense v_c, multiply it with $1/a$ and subtract it from v_d, one can eliminate the interference. This is exactly what the Cioffi and Amrany patents teach in this example.

The Cioffi system breaks down when the received signal suffers from more than one dominant disturber (e.g., two dominant NEXT disturbers present in the cable binder). The Cioffi system's failures in the regard are substantial. In this case the differential voltage is

$$v_d = s + i_1 + i_2 \quad (3)$$

When the common mode voltage also senses a mixture of those disturbers then:

$$v_c = bi_1 + ci_2 \quad (4)$$

Notice that the two disturbers couple with different amplitudes (b and c) to the common mode than the differential mode. Further, notice that the two disturbers vary independent of each other, so that it is not possible to simply group both disturbers into a single disturbance i. It is clear from equations (3) and (4) that if b is different from c, a scalar can not be found that can multiply the common mode voltage v_c, such that it can cancel the interference when subtracted from v_d. Hence, Cioffi can not be extended to a multi-channel system as is claimed where each filter receives multiple inputs.

This example illustrates the limitation of the Cioffi patent and the Amrany patent. In contrast, if we assume that we have two pairs (according to the teachings of the current application), in the same example we can obtain two common mode voltages

$$v_{c,1} = b_1 i_1 + c_1 i_2 \quad (5)$$

$$v_{c,2} = b_2 i_1 + c_2 i_2 \quad (6)$$

where the disturbers will not couple into both pairs with the same coupling strengths denoted by the b's and c's. In this case, the claimed system jointly processes the signals from the two common mode voltages, here collected in a vector

$$\begin{bmatrix} v_{c,1} \\ v_{c,2} \end{bmatrix} = \begin{bmatrix} b_1 & c_1 \\ b_2 & c_2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} \quad (7)$$

For example, the interference components can be recovered by processing equation (8)

$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} b_1 & c_1 \\ b_2 & c_2 \end{bmatrix}^{-1} \begin{bmatrix} v_{c,1} \\ v_{c,2} \end{bmatrix} \quad (8)$$

when the coupling matrix is invertible, and of course further cancel each disturber from the differential voltage of interest. This argument can be generalized to more than two common mode voltage sensors, canceling interference that contains more than two dominant components.

As is clear from this example, a multipair noise cancellation is quite different from a single pair one in both its attributes and its uses. In particular, it is not a trivial extension of the single pair case for the following reasons:

- A different and more complicated processing architecture has to be envisioned, to jointly process the common mode signals, as opposed to replicating a single pair processing for each pair.

- A substantially more complicated operation is performed including identifying the components of the interference and subtracting each component from the signal of interest. In one embodiment, this is all accomplished via matrix filtering operations.

- A substantially different space of applications opens up with multipair joint processing. Noise cancellation is no more limited to a single interferer (radio interferer in Cioffi, or dominant NEXT interferer in Amrany) and is no more applicable only to the customer premises modem. Given the ability to cancel multiple interferers, this solution becomes applicable to a central office environment, where multiple interferers are a common occurrence.

It is important to point out that the multiple input signal filter processing in the multi-pair system as claimed is different then simply replicating the system of the Cioffi patent for each channel. If the Cioffi reference is extended to each channel, then each channel would have a dedicated filter that would not receive input from other channels. In the claimed system and as set forth in Figure 17, this is not the case.

Claim 1

The Applicants have amended Claim 1 to require that the signals be received over conductor pairs. In addition, Claim 1 requires that filtering occur for each conductor pair on the two or more common mode components to create a cancellation signal associated with each conductor pair. As discussed above, this is not taught by the prior art and as such, the Applicants request allowance of Claim 1 and Claims 2-5 which depend from Claim 1.

Claim 6

The Applicants have amended Claim 6 to require that two or more channels comprise one or more conductive paths. In addition, the processing step now requires that processing occur on the common mode component and at least one common mode component from another channel. As discussed above, this is not taught by the prior art and as such, the Applicants request allowance of Claim 6 and Claims 7-10 which depend from Claim 6.

Claim 11

The Applicants have amended Claim 11 to require that each filter receive two or more common mode components and process these two or more common mode components to generate a cancellation signal. These prior art cited by the Examiner does not teach joint filtering multiple common mode signal to create a cancellation signal and such a configuration is not an obvious variation of the Cioffi reference. As such, the Applicants request allowance of Claim 11 and Claims 12-16 which depend from Claim 11.

Claim 17

The Applicants have amended Claim 17 to require filtering of two or more isolated common mode signal to create a cancellation signal. As set forth above, the cited references to not teach this element not would it be an obvious variation. Consequently, the Applicants request allowance of Claim 17 and Claims 18-24, which depend from Claim 17.

Claim 24

The Applicants have amended Claim 24 to require joint filtering of at least two isolated common mode components to create a cancellation signal. The cited prior art does not teach or make obvious joint filtering of at least two isolated common mode components. As a result, the Applicants request allowance of Claim 24 and Claims 25-26, which depend from Claim 24.

SUMMARY

Applicants assert that Claims 1-26 are in a condition for allowance and respectfully requests a notice as to the same. If any matters remain outstanding, the Examiner is invited to contact the undersigned by telephone.

Respectfully submitted,

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